HPB, 2006; 8: 35–37

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Liver hanging maneuver for right hemiliver *in situ* donation – anatomical considerations

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Abstract

Background. An anatomical study was carried out to evaluate the safety of the liver hanging maneuver for the right hemiliver in living donor and *in situ* splitting transplantation. During this procedure a 4–6 cm blind dissection is performed between the inferior vena cava and the liver. Short subhepatic veins entering the inferior vena cava from segments 1 and 9 could be torn with consequent hemorrhage. *Materials and methods.* One hundred corrosive casts of livers were evaluated to establish the position and diameter of short subhepatic veins and the inferior right hepatic vein. *Results.* The average distance from the right border of the inferior vena cava to the opening of segment 1 veins was 16.7 ± 3.4 mm and to the entrance of segment 9 veins was 5.0 ± 0.5 mm. The width of the narrowest point on the route of blind dissection was determined, with the average value being 8.7 ± 2.3 mm (range 2–15 mm). *Discussion.* The results show that the liver hanging maneuver is a safe procedure. A proposed route of dissection minimizes the risk of disrupting short subhepatic veins (7%).

Key Words: *Liver hanging maneuver, inferior vena cava, corrosive cast, liver transplantation*

Introduction

The anterior approach to right hemihepatectomy without liver mobilization is gaining popularity in living donor transplantation and *in situ* splitting as a way of avoiding excess handling of the liver. The approach using the recently described liver hanging maneuver [1] has been evaluated by an anatomical study. During this procedure a 4–6 cm blind dissection between the inferior vena cava (IVC) and the liver is performed. This maneuver has raised concerns among surgeons that the short subhepatic veins, which enter the IVC from segment 1 and segment 9 (right paracaval region), may be torn. The anterior approach to the liver with parenchymal transection from the anterior liver surface through to the IVC has many advantages in right hemihepatectomy. There is no compression or rotation of the graft and remnant liver tissue during right hemiliver retrieval compared with standard mobilization of the liver [2,3]. Lifting the liver with a tape, passed between the anterior surface of the IVC and the liver parenchyma, is a valuable method in the anterior approach when controlling bleeding from the deeper parenchymal plane [1] and in guiding the resection. An anatomical study was carried out to evaluate the safety of this approach and to look for variations in hepatic vein anatomy that would be of importance to the liver surgeon.

The terminology used in the article is the Brisbane 2000 Terminology of Liver Anatomy and Resections [4].

Materials and methods

We prepared 100 corrosive casts of livers, removed during autopsies from the bodies of subjects without previously known liver disease. Prior permission was obtained from the National Ethical Commission. The method has already been described [5,6].

The anterior surface of the IVC between the entry of the lowest up to the entry of the highest hepatic vein was studied. The parameters considered were as follows: the length of the retrohepatic portion of the IVC from the inflow of the superior right hepatic vein (SRHV) to the inflow of the lowest hepatic vein; the distance between the SRHV and middle hepatic vein (MHV) or common trunk when present; the frequency of the inferior right hepatic vein (IRHV) and its influence on the number of short subhepatic veins and on the wideness of the dissection route; the number and diameter of short subhepatic veins from segments 1 and 9; the distance of segment 1 veins from the right border of IVC; the distance of segment

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ISSN 1365-182X print/ISSN 1477-2574 online
DOI: 10.1080/13651820500465931

9 veins, entering the anterior surface of the IVC, from the right border of the IVC; and the width of the narrowest point on the route of blind dissection.

Mean values with standard deviation were used for numerical data. The length of the retrohepatic portion of IVC in cases with and without IRHV and diameters of segment 1 and segment 9 veins were compared by Student's t test. $p < 0.05$ was considered to be statistically significant.

Results

The mean length of the retrohepatic portion of the IVC from the inflow of the SRHV to the inflow of the lowest hepatic vein was significantly longer when the IRHV was present. It was 61.5 ± 9.5 mm versus 51.3 ± 10 mm ($p < 0.001$).

The mean distance between SRHV and MHV or common trunk was 10.9 ± 2.3 mm (range 5–18).

In 33 cases (33%) we found a substantial IRHV which predominantly drained segment 6. Its mean diameter was 7.0 ± 2.1 mm with a maximum value of 13 mm. The IRHV entered the IVC on its right border in 18% and on its anterior surface in 82% of cases. When the IRHV was present, there was no difference in the number or position of short subhepatic veins from liver segment 1 compared to the casts without IRHV. Segment 9 veins draining directly into the IVC were present in 21% of cases when the IRHV was present and in 58% of cases when the IRHV was absent. If we 'removed' IRHV from the casts, the right side of the anterior surface of the IVC would become free for dissection in 91% of the cases, and the mean width of the dissection route would be 12.0 ± 2.1 mm.

Short subhepatic veins from liver segment 1 (1–5, median = 2), draining directly into the IVC, were always present. By contrast veins from liver segment 9 predominantly drained into the SRHV via its tributaries (64%), but in addition there were also 1–4 (median = 2) small veins from segment 9 directly entering into the anterior surface of the IVC in 82% of cases. The mean diameter of short subhepatic veins draining segment 1 was 3.1 ± 0.8 mm and of those draining segment 9 was 1.7 ± 0.6 mm with the difference being statistically significant ($p < 0.05$).

Short subhepatic veins from segment 1 entered the anterior surface of IVC from its left side. The distance measured on average of 16.7 ± 3.4 mm and was never less than 9 mm from its right border (Figure 1). Short subhepatic veins draining liver segment 9 were more often present when the IRHV was absent. In 37% of cases they entered the right border of the IVC, and consequently the anterior surface was free for dissection. When they entered the anterior surface of the IVC they presented a dangerous zone for blind dissection which extended 5.0 ± 0.5 mm from its right border, to a maximum value of 9 mm (Figure 1).

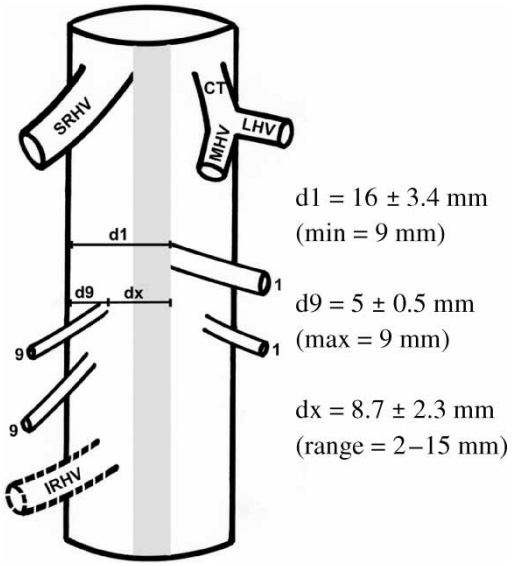

Figure 1. Anterior surface of the retrohepatic inferior vena cava (IVC). Dissection route is shown in gray. d1, mean distance from the entrance of segment 1 veins to the right border of IVC; d9, mean distance from the entrance of segment 9 veins to the right border of IVC; dx, mean width of the narrowest point on the route of blind dissection; SRHV, superior right hepatic vein; IRHV, inferior right hepatic vein; CT, common trunk; MHV, middle hepatic vein; LHV, left hepatic vein; 1, 9, veins from segments 1 and 9.

The mean value of the narrowest point on the route of blind dissection on the anterior surface of IVC was 8.7 ± 2.3 mm (range 2–15) (Figures 1 and 2). We considered the ideal route of dissection to be parallel to the right border of IVC starting 10 mm from it or from the most medial point of IRHV entrance, if the vein entered >10 mm from the right border. In 93% of cases we found this route to be the best choice. In 7% of cases we found the angle of 5° toward the right border of IVC with the point of the angle being the most medial point of SRHV entrance to be the better choice, but the dissection parallel to the right border of IVC would still be possible, although in these cases the narrowest point of dissection was between 2 and 4 mm.

Discussion

Right hemihepatectomy, performed as a conventional operative procedure, requires a complete mobilization of the right hemiliver and exposing the retrohepatic IVC to enable control and ligation of the hepatic veins located on the right side of the IVC. Mobilization of the liver with rotation of the right hemiliver leads to compression of the parenchyma and temporary inflow and outflow blood obstruction. A deleterious effect on the liver graft and remnant liver tissue in living donor and *in situ* splitting transplantation is the result of such manipulation. In addition, liver mobilization to resect large right hemiliver tumors near the IVC may cause tumor dissemination [3] and tumor rupture [7]. The anterior approach to parenchymal transection from the anterior surface of the liver down to the IVC

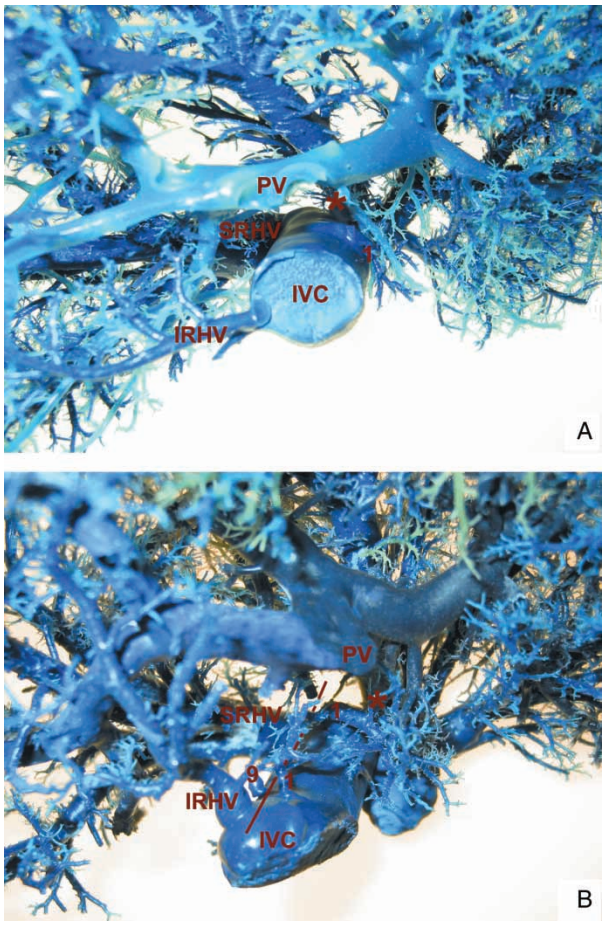

Figure 2. Caudo-cranial view to the anterior surface of the inferior vena cava. (A) Wide dissection route, there are no short subhepatic veins on it; (B) narrow dissection route, entrances of the inferior right hepatic vein and veins from segments 1 and 9 are close to the dissection line (red). IVC, inferior vena cava; SRHV, superior right hepatic vein; IRHV, inferior right hepatic vein; *, entrance of middle hepatic vein; 1,9, hepatic vein from segment 1 and 9; PV, portal vein.

[2,7] has become an important alternative to the conventional approach to the right hemihepatectomy. Although blood loss and transfusion requirements are lower in patients with the anterior approach [7], potentially severe bleeding during parenchymal dissection may be encountered. The hanging maneuver introduced by Belghiti and co-workers [1] represents a potentially important advantage to the liver resection technique. The main concern in using this maneuver is the blind dissection through the predominantly avascular area in the midline of the anterior surface of the retrohepatic IVC.

The results of this study show that the liver hanging maneuver is a safe procedure and can be used in clinical practice. However, there are some anatomically important aspects to consider in the procedure. The anterior surface of suprahepatic IVC, SRHV and MHV or common trunk has to be exposed. The downward dissection between SRHV and MHV is safe for 2.5 cm, as there are no short subhepatic veins in this area. It is important to dissect in the longitudinal axis of IVC, parallel to its right border, from the most medial point of entrance of SRHV.

The ligation of segment 1 veins is not obligatory, as those veins that are present do not compromise the dissection route. They must be ligated only when the resection is extending to segment 1. The potential presence of the IRHV is more important. It has no influence on segment 1 veins but segment 9 veins were more often present if IRHV was absent.

The upward blind dissection of the avascular plane should start approximately 10 mm from the right border of the IVC or from the left side of the IRHV entrance toward the already prepared space between SRHV and MHV. The dissection route should be parallel to the right border of the IVC. According to the results of this study dissection on the left side of the anterior surface of the IVC is not recommended for two reasons. Segment 1 veins entering the anterior surface of the IVC are always present and their mean diameter is significantly bigger than the diameter of the veins draining segment 9. With the blind dissection along the proposed route the risk of disrupting short subhepatic veins is low (7%) and bleeding is easier to control from segment 9 veins with their smaller diameter. The venous drainage of segment 1 is also spared.

Nevertheless, it is clear that the avascular plane on the anterior surface of IVC is restricted in a small number of cases with the narrowest point of dissection along the route being 2 mm in diameter.

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